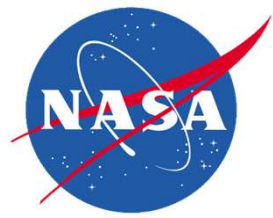


UV Laser Development for *in situ* Planetary Lander Instruments



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CORALS Team, CRATER, Team, RAMS Team, PLASMA Team

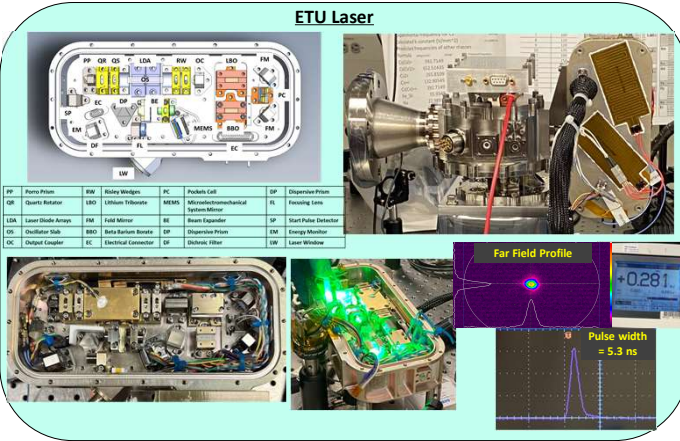
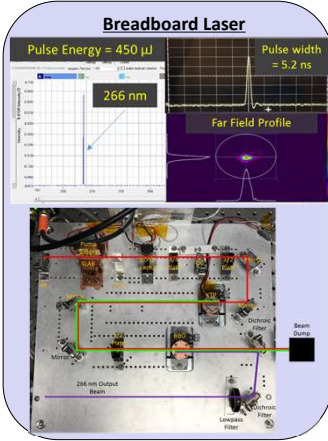
OVERVIEW & MOTIVATION

Mass and Raman spectrometer instruments are being developed for future *in situ* lander missions to explore the surface chemistry of planetary bodies across the Solar System. Europa, the Moon, and Mars are some of the primary targets for future NASA missions to search for extraterrestrial life and potentially habitable environments beyond Earth, further our understanding of the timing and formation of the Solar System and identify potentially viable economic resources such as water and/or valuable metal assets.

Ultraviolet Laser Development Programs

Instrument	Instrument Description	Laser Wavelengths	Funded Program	PI
CORALS	UV laser-enabled Orbitrap™ mass spectrometer	266 nm	ICEE-2	R. Arevalo Jr/UMD
CRATER	UV laser-enabled Orbitrap™ mass spectrometer	213 nm	DALI	R. Arevalo Jr/UMD
RAMS	Microimaging laser desorption/ionization mass spectrometer (LDMS) and Raman spectrometer hybrid	257.5 nm, 515 nm	PICASSO	A. Grubisic/699
PLASMA	Laser ablation system, plasma mass spectrometer, and in-line collision cell	213 nm, 266 nm, 532 nm, 1064 nm	DALI	W. McDonough/UMD

CORALS (Characterization of Ocean Residues and Life Signatures) Laser



CORALS Europa Science Objectives:

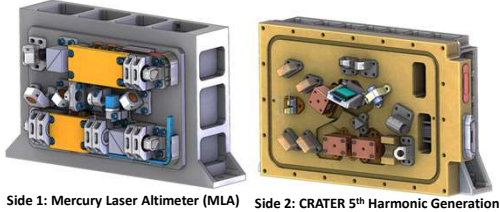
1. Analyze abundance patterns, distributions, and diversity of organics
2. Constrain sample provenance and assess the probability of biological origin
3. Identify mineralogy and map chemical heterogeneity across samples
4. Evaluate mass transfer and/or isotopic exchange across the crust-ocean interface
5. Monitor physicochemical changes in sample properties overtime

Initial ETU Laser Performance (pre-DHMR)

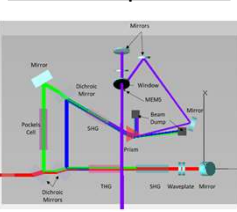
Pulse Energy	0-280 μJ (variable)
Pulse Width	5.3 ns
Spot Size (1/e ²)	~60 μm
Wavelength	266 nm
Beam Scanning	±6 deg

CRATER (Characterization of Regolith and Trace Economic Resources)

CRATER ETU CAD Model



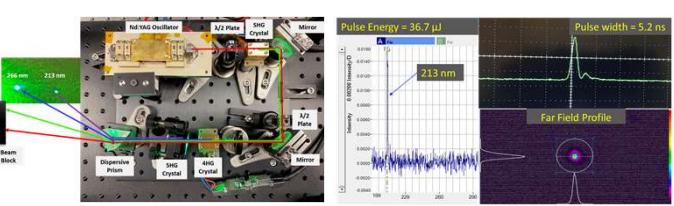
CRATER ETU Optical Model



CRATER Laser Requirements

Laser Baseline	MLA MOPA
Output Wavelength	213 nm
Pulse Energy	>1 mJ
Beam Spot Size	50 μm
Peak Intensity	50 J/cm ²
Pulse Rate	1-10 Hz
Energy Attenuation	1-100%, 5% Steps
Beam Steering	±5°

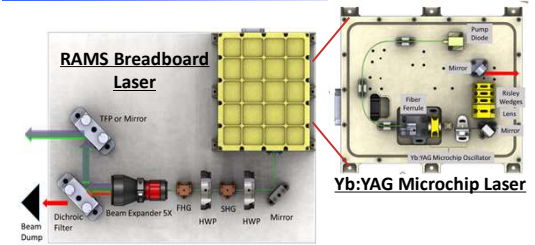
CRATER Breadboard Demonstration and ETU Model Predictions



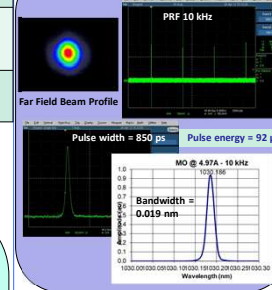
CRATER Lunar Science Objectives:

1. Define the lunar inventory of refractory (e.g., Uranium) and volatile elements (e.g., Potassium)
2. Characterize abundances/distributions/structures of exogenous organics
3. Track water and valuable metal resources in lunar surface materials

RAMS (Raman Mass Spectrometer)



1030 nm Laser Performance



RAMS Unique Capabilities

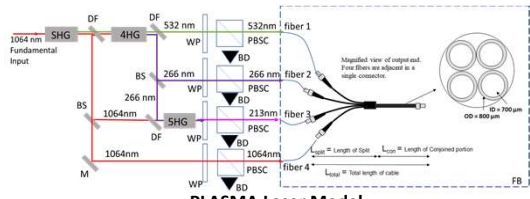
- Organic composition over wide range of molecular weights from 1-2000 Da
- Structural characterization of organic compounds
- Macromolecular carbon (MMC) detection
- Mineral identification and specificity even in case of stoichiometrically similar minerals.
- Microimaging (~10 μm resolution) capabilities for inorganic/organic composition mapping.

RAMS Laser Requirements

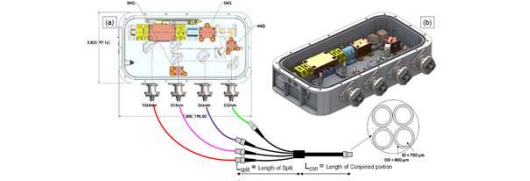
Parameter	DUV	VIS
Wavelength	257.5 nm	515 nm
Fluence Range (variable)	0.02 - 1.0 J/cm ²	0.01 - 1.0 J/cm ²
Spot Size (1/e ²)	≤ 10 μm (along short projection axis)	
Shot-to-shot stability	≤ 10 % (Goal: ≤ 5%)	
Pulse Rate	1-10 kHz (selectable)	
Spectral Bandwidth	≤ 0.02 nm	
Beam Steering	± 6°	

PLASMA (PULSED LASER ABLATION SAMPLING AND MASS ANALYSIS)

PLASMA Laser Concept



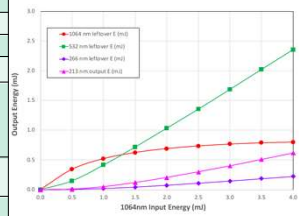
PLASMA Laser Model



PLASMA Laser Requirements

Oscillator Type	LOLA
Mission Lifetime	10 ⁶ shots
Pulse Width	<6 ns
Spot Size (1/e ²)	40 μm
Wavelengths & Pulse Energy	1064 nm: 120 μJ 532 nm: 0.12 μJ 266 nm: 120 μJ 213 nm: 120 μJ
Energy Attenuation	1-100%, 5% steps
Beam Steering	±5°

Non-linear Optical Model



Plasma Instrument Capabilities:

- (1) Spatially resolved sampling, 2D chemical imaging of lunar materials, and emission of multiple wavelengths for enhanced photon-substrate coupling;
- (2) Quantitative analysis of major, minor, and trace elements across the periodic table (6Li to 238U) to higher precision and accuracy than previous spaceflight investigations; and,
- (3) Discrimination of isobaric interferences via collision cell technology to separate competing elemental and isotopic signals and enable Rb-Sr radiometric dating.